Int J Life Cycle Assess (2013) 18:263–272
DOI 10.1007/s11367-012-0460-5

SUSTAINABLE DEVELOPMENT

Towards stronger measures for sustainable consumption and production policies: proposal of a new fiscal framework based on a life cycle approach

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Received: 20 December 2010 / Accepted: 12 June 2012 / Published online: 20 July 2012

Abstract
Purpose The sustainable development challenge that many economies are facing worldwide requires stronger measures because some environmental issues (e.g. global warming) are becoming exponentially worse. If we do not act at once, this negative trend has the potential to keep on radically changing the living conditions on the Earth. One of the most effective ways to address this challenge might be developing new Market Based Instruments (MBIs) by adopting a life cycle perspective. In this paper, we propose a new fiscal framework based on Value Added Tax (VAT) and life cycle thinking. This framework might have the potential to drastically change the current consumption and production patterns towards a product life cycle oriented economy.
Methods To identify the elements of a new framework enabling to improve the eco-efficiency of the current consumption and production patterns, firstly we have screened the potential of MBIs to face the sustainable development challenge in relation to the existing EU policy framework. Among MBIs, particular emphasis was given to VAT due to its potential to affect market prices. The key research advances for establishing a green VAT framework were then tracked down to outline the state-of-the-art. Moreover, how to use Life Cycle Assessment (LCA) results for differentiating VAT rates has been investigated. On this basis, a range of methodology proposals to change the current VAT framework have been outlined. A hypothetical case study has been simulated to test these proposals.
Results Some relevant changes to the current VAT taxation system are proposed in this paper bearing in mind the LCA principles and, in a broad sense, the "getting prices right" policy. Special emphasis was given to the methodological framework needed to differentiate VAT rates according to the environmental footprint performance of products. In this context, fiscal neutrality issues related to State budgets have been also taken into account by conceptualising more cautious approaches for differentiating VAT rates.
Conclusions This piece of research has identified life cycle thinking as possible perspective on which basis product VAT rates might be differentiated. Further studies and a policy impact assessment procedure are needed to evaluate the actual feasibility of this new taxation framework. If the response of that assessment were positive, policy makers, companies and other stakeholders concerned should set out a suite of measures to further fine-tune, test, establish and facilitate the implementation of such green VAT framework.

Keywords Carbon footprint · Eco-efficiency · Environmental product declaration · Green VAT · Life cycle assessment

1 Introduction

In the framework of the EU sustainable development policies and green growth measures to a resource-efficient Europe (EC 2009a, b; EC 2011a; EC 2011b), the "Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) Action Plan" (EC 2008) is a building block in the EU policy framework. In this context, a wide range of instruments has been established and, among others, Market Based Instruments (MBIs) look promising to face the

Responsible editor: Bastian Wittstock

The views expressed in the article are personal and do not necessarily reflect an official position of the European Commission.

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challenge of integrating environmental sustainability with economic growth and welfare. In particular, decoupling environmental degradation from economic growth and doing more with less are relevant of MBIs and, among others, environmental taxes and incentives seem particularly effective for meeting the green growth challenge in a shorter term.

As no methodology has been developed so far to integrate life cycle thinking into any indirect taxation form, in this paper we propose a new fiscal framework based on a variable Value Added Tax (VAT) rate depending on the product environmental performance.

To better understand the policy framework in which the proposed fiscal system might be positioned, and to figure out why we focused on MBIs, a short rationale is given in section 2. The state-of-the-art of the advances in developing a green VAT is outlined in section 3. In that section, the reasons why a green VAT might be an effective MBI are also highlighted. Section 4 underlines the need of building upon the Life Cycle Assessment (LCA) methodology to reform VAT for a green indirect taxation framework. The newly developed LCA-based methodology to differentiate VAT rates according to the environmental performance of products is then presented in section 5. In particular, some equations for calculating such rates are presented. In that section, a series of additional components to make the taxation framework viable are also proposed. To show how this methodology could work in practice, a hypothetical case study was simulated and the results are illustrated in section 6. Finally, some implications and perspectives related to the introduction of the taxation framework are briefly analysed in section 7.

2 About the need of going for market based instruments

Together with a high level of prosperity and social cohesion, environmental protection is becoming a fundamental objective of an increasing number of countries. This tendency is reflected in many agreements, policies and laws that address the three pillars of sustainable development (i.e. economic, environmental and social). In the EU, sustainable development is a long-term objective (EC 2009a, b), and the concern for it is mainly addressed by policies in the field of environmental protection (referring to e.g. climate change, water, soil, waste, biodiversity and so forth).

Although sustainable development can be addressed from many angles, one of the most important remains at the consumption and production level, which has been mentioned in many EU policies. Already in the 6th Community Environment Action Programme (EC 2002), which set up the framework for the environmental policy in Europe in 2002–2012, it is mentioned that unsustainable consumption and production patterns that negatively influence the environment should be changed. This includes the internalization of environmental impacts (both negatives and positives) through the use of different instruments, among others, those market based. The importance of the sustainable consumption and production paradigm has been highlighted in the SCP/SIP Action Plan (EC 2008) and reiterated in the roadmap to a resource-efficient Europe (EC 2011b). The European Council conclusions on the SCP/SIP Action Plan (Council 2008) clearly have indicated the hierarchy of preferences regarding the use of available instruments to support the implementation of the SCP/SIP Action Plan. It has placed the highest priority on voluntary instruments like e.g. eco-labels and environmental certification schemes (e.g. ISO 14001:2004, EMAS). The second priority was given to the industry self-regulation, and the third to MBIs. According to the World Bank (1997), MBIs are both those instruments able to influence prices on the markets (e.g. subsidies, environmental taxes, user fees), and those instruments that create new markets (e.g. tradable permits or international offset systems). Finally, the lowest priority was given by the Council (2008) to regulatory instruments (e.g. standards, bans or quotas), which should be used only if necessary.

As implementing voluntary instruments and industry self-regulation actions may not be sufficient to mitigate climate change on time, and to prevent further massive environmental changes (e.g. biodiversity losses), stronger measures are increasingly necessary for sustainable development. These measures may include MBIs, regulatory instruments or a combination of all types of the above-mentioned instruments.

MBIs are of particular interest because their implementation has proven to be less costly than e.g. regulatory instruments (World Bank 1997). The European Commission is increasingly interested in adopting MBIs, such as indirect taxation forms, targeted subsidies or tradable emission rights (EC 2007; Kosonen and Nicodème 2009). A more intensive use of MBIs has been also advocated in the EU's 6th Environment Action Programme (6th EAP; EC 2002) and the renewed EU Sustainable Development Strategy (EC 2005a, b), as well as the renewed Lisbon Strategy for Growth and Jobs (EC 2005a, b). Compared with regulatory instruments, MBIs present a number of advantages (EC 2007):

- Pollution levies (taxes, fees and fines) induce each polluter to reduce the environmental impact up to the point where the marginal cost of pollution abatement is equal to the levy. In this way the costs of reaching a given environmental target are minimised (static efficiency);
- Organisations can choose the level and the method of pollution abatement (flexibility);

- Imposing levies normally requires less detailed information than regulation and thus entail lower administrative costs;
- MBIs set a price on each unit of pollution / emissions and thus induce firms to constantly improve environmental performances and to invest in less-polluting technologies. This is a powerful incentive for innovation (dynamic efficiency).

Amongst MBIs, indirect taxes can be very effective in making consumer' behaviour more sustainable (Kosonen and Nicodème 2009). Taxes, in fact, could positively affect prices of products by guiding consumers to choose environmentally-friendly products. MBIs are, thus, essential instruments to solve those market failures occurring worldwide due to the lack of incorporation of the environmental burden of products into their market price. In a broad sense, MBIs such as VAT have the potential to address the "getting prices right" issues mentioned in the Community Sustainable Development Strategy (EC 2005a, b). According to this policy and inline with the polluter pays principle, "the environmental performance of products can be best optimised by the market once all prices reflect the true environmental costs of products during their life cycle" (EC 2001).

3 The potential of VAT in the context of sustainable consumption and production policies

A key measure envisaged in the EU Green Paper on the Integrated Product Policy (IPP) (EC 2001) was the creation of a product taxation system that takes into account the environmental performance of goods and services. In this context, VAT has been the main taxation form analysed so far by researchers and policy makers (Albrecht 2006; Næss-Schmidt et al. 2008; Oosterhuis et al. 2008).

The main reason why VAT is considered as one of the most appropriate instruments to support the way towards sustainable consumption is that consumption taxes have relatively broad taxation base: according to Eurostat data, final consumption expenditures account for almost 80 % of GDP in EU-27. It is also important that the institutional and operational framework for managing the VAT already exists, saving thus the costs of introducing new tax systems.

Moreover, linking VAT to the environmental performance of products might knock down the "invisible" market barriers for some eco-friendly products. In many cases, these products are more expensive than the conventional ones. This is due to the fact that the eco-friendly products have been produced e.g. in compliance with stricter environmental laws in certain countries, or by using raw materials with better eco-profiles that may cost more than the conventional ones.

To address this issue, Albrecht (2006) developed a methodology to equalise price gaps between environmentally-friendly products and cheaper substitutes by increasing VAT rates of the latter. Two studies commissioned by European Commission (Næss-Schmidt et al. 2008; Oosterhuis et al. 2008) also analysed the impact of using differentiated VAT rates for products, but without dealing with the methodology to differentiate VAT rates on the basis of a life cycle approach.

4 Building a green VAT framework upon LCA

Although there are different methodologies available, there is a general consensus to recognise LCA as one of the most robust approaches to assess the environmental impacts generated by products (Azapagic and Clift 1999; EC 2001; Rebitzer et al. 2004; Hunkeler and Rebitzer 2005; Finnveden et al. 2009). In fact, according to the reference international standards (ISO 14040:2006 and ISO 14044:2006) guidelines by the European Commission (EC 2010), all product life cycle phases (e.g. extraction of the raw materials, pre-production processing, production, consumption, end-of-life) and a wide range of environmental loads (i.e. energy and resource use, airborne emissions, wastes, releases to soil and water) are considered in the LCA methodology to quantitatively assess the potential environmental impacts in terms of e.g. global warming, human and environmental toxicity, natural resource depletion, ozone layer depletion, summer smog. These features render LCA a unique methodology able to detect and track most of burden shifts along the product life cycle stages or across the individual impact categories analysed.

In terms of environmental mechanisms considered and inherent methodological robustness, LCA is certainly a scientific methodology up to the characterization phase where performance indicators are calculated for a number of environmental impact categories (midpoint indicators) on the basis of scientifically sound impact assessment methods. Based on high quality reference values, the normalization step has also the potential to be characterised by a certain scientifically soundness. Contrarily, subjective considerations reflecting the importance of each impact category render the grouping and weighting steps not objective.

Taking into account the stepwise procedure of the LCA methodology as well as the scientific soundness behind its framework, we can conclude that, a VAT rate can be mainly derived on the basis of:

- A single score indicator coming out from the weighting phase (see comments below).
- A selected impact category indicator (e.g. global warming potential) from the characterization phase.

Although there is no objective basis for obtaining a single score indicator from the weighting procedure, we believe that VAT rates based on a single score indicator may be defendable if weighting is performed in a transparent and consistent way. Moreover, the decision about the weights associated to each impact category may fall into the domain of policy-making as those weights can be related to the priorities set within the policy framework. Although there is no consensus about weighting from the natural science perspective so far, such a consensus might be reached among policy-makers first. The process of reaching the approved weighting scheme falls outside of the scope of this paper.

5 Setting up a new fiscal framework

Going beyond the Albrecht's (2006) insights and other advances in the field of green VAT (see section 3), in this section we present some methodology proposals to differentiate VAT rates according to the environmental performance of products as well as a series of components to make the taxation system viable.

5.1 Methodology proposal 1: a multiple impact categories-based framework

On the basis of a single score environmental indicator (see section 4) coming out from the weighting phase, VAT rates might be calculated using Eq. (1). According to this equation, every 1 % of difference in product environmental performance corresponds to a 1 % VAT difference. In this context, VAT might be not only considered as an indirect tax affecting the prices of environmentally damaging products, but also an incentive to promote the eco-friendly ones. In fact, Eq. (1) may give negative results if the environmental performance of the analysed product is smaller than the environmental performance of reference product.

$$VATx = VATsr - \left(\frac{Ia - Ix}{Ia}\right) \quad (1)$$

where:

VATx	VAT rate (expressed in decimal form) of the product x in the year n
VATsr	VAT standard rate (expressed as a decimal)
Ix	single score environmental indicator (dimensionless) of the product x in the year n
Ia	single score environmental indicator (dimensionless) as reference environmental performance for the product category x in the year $n-1$ (benchmark).

5.2 Methodology proposal 2: a carbon footprint-based framework

If a midpoint impact indicator were considered more robust than the one illustrated in the previous section, the VAT rate could be calculated on the basis of a selected impact category indicator. This approach addresses the concerns related to the fact that the procedure to calculate a single score environmental indicator may not take into account the actual maturity level of the individual impact assessment methods from which the single score environmental indicator derives. In addition, so far there is no general consensus on the actual weight of each environmental impact category. Worldwide the choice of this specific impact category might be driven by the current concern on global warming and the consequent need of establishing stronger measures for a low carbon economy. Sticking to the characterization phase, VAT rates might be related to the carbon footprint of products (i.e. only greenhouse gases emissions are accounted) by using Eq. (2). Whenever this equation gives a negative value, an incentive equal to the negative rate applies to the product analysed.

$$VATx = VATsr - \left(\frac{GWa - GWx}{GWa}\right) \quad (2)$$

where:

VATx	VAT rate (expressed in decimal form) of the product x in the year n
VATsr	VAT standard rate (expressed in decimal form)
GWx	carbon footprint indicator (Kg CO_2-Equiv.) of the product x in the year n
GWa	reference product carbon footprint indicator (Kg CO_2-Equiv.) of the product category x in the year $n-1$ (benchmark)

5.3 Methodology proposal 3: more cautious approaches with regard to the State budget

As far as the previous proposals are concerned, the potential financial impact of this reform on public finance should be carefully analysed. For instance, State budget could be negatively affected by a large use of incentives in case of a contextual significant improvement of eco-efficiency in several sectors. However, in this paper we limit ourselves to point out possible implications on the budget incomes, since it would require a separate discussion.

To avoid these budgetary issues, a more cautious VAT framework could be set up. For instance, environmentally damaging products could be taxed in the same way as proposed, whilst eco-friendly goods and services might benefit from incentives whose amount either cannot exceed a certain negative VAT rate (e.g. −20 % as maximum

incentive rate) or corresponds to the standard VAT rate. In the latter case, 0 % VAT rate applies to eco-friendly products. Alternatively, an expected rate of eco-efficiency improvement per each product category could be integrated into the above-mentioned equations to properly take into account eco-innovation of technologies and techniques. Finally, a further solution could be to integrate into the equations a set of multiplicative factors to overtax environmentally damaging products.

5.4 Additional components for a green VAT framework

Besides the above proposals to calculate product specific VAT rates, some governing rules are needed to make this new taxation framework viable.

First of all, organisations should be asked to elaborate product environmental performance declarations (i.e. a sort of product-specific environmental identity card) on a yearly basis and in line with ISO 14044:2006 and ISO 14025:2006. Nevertheless, deviations from ISO 14025:2006 (e.g. concerning the assessment scope) may be needed in some cases to allow data exchange synchronization between organisations, and avoid double counting. More detail is given below.

Generally speaking, environmental product declarations (EPDs) are needed to facilitate data collection as well as to allow the comparison of suppliers' environmental performance. In this way, the environmental performance of products could be improved by choosing both raw materials and energy carriers that are more eco-friendly, in addition to environmental improvements made in the internal production processes through eco-innovation. Data in EPDs should be systematically documented and reported in an aggregate way in order to ensure information confidentiality. Making EPDs mandatory may be perceived as an additional administrative burden, especially by SMEs. This is a major issue that could be addressed by making data available, as illustrated below, and by developing ad hoc tools to elaborate data and issue EPDs. Moreover, if production processes and suppliers has not changed since the preceding year, EPDs may remain valid if still representative for the analysed year. For this purpose, the ILCD Handbook (European Commission 2010), and existing sector- and product-specific guidance documents, could be used as reference technical guidance documents to ensure coherent calculations and comparable assessments.

In this context, the role of each organisation within a certain supply chain (see Fig. 1 for a simplistic example of supply chain including use/consumption and product end-of-life phases) should be clearly identified in order to end up with differentiated VAT rates for products at the point of sale. The actual environmental assessment methodology should reflect such conceptual framework. In particular, as shown in the upper part of Fig. 2, companies in the extractive industry should be asked to conduct from-cradle-to-gate assessments in order to come out with their EPDs. These declarations should be then delivered to their customers (i.e. manufacturers of semi-finished products or components). By collecting EPDs from suppliers, the manufacturers of semi-finished products or components are facilitated to conduct their own from-cradle-to-gate product environmental assessments, as shown in the middle of Fig. 2, and to come out with their own EPDs to be delivered to manufacturers of finished products. The latter organizations should carry out from-cradle-to-grave product environmental assessments (see the lower part of Fig. 2) because they normally package finished products. To facilitate the implementation of these full baseline assessments, data should be made available by suppliers and public authorities. In particular, data should come from:

- EPDs as far as upstream unit processes are concerned;
- Reference average LCI databases (e.g. ELCD) only for the most commonly used unit processes such as energy carriers, water supply, transport modes and product end-of-life unit processes. In addition, high-quality secondary data are to be used whenever only low-quality primary data are available (e.g. GHG emissions from cow breeding);
- Reference statistics and LCI datasets for retail, use/consumption, product end-of-life and transport processes between the previous life cycle phases. Organisations involved in these phases may be asked to issue EPDs in order to allow dataset providers to come out with reference datasets.

A public authority with environmental competencies might ensure an effective functioning of the amended VAT framework. Such an organisation should be in charge of inspecting environmental declarations by using e.g. sectorial studies monitoring the average environmental performance for each product category (benchmark). This authority should also provide organisations with accurate reference environmental indicators for product categories (*Ia* or *GWa*). If the carbon footprint-based VAT framework (see Eq. (2) and Eq. (4)) were chosen, the issue of shifting environmental burdens from global warming to other environmental issues could become a major problem. Some organisations, in fact, could decide to solely improve their own environmental performance in terms of global warming to the detriment of other environmental issues in order to benefit from the lower VAT rate and, hence,

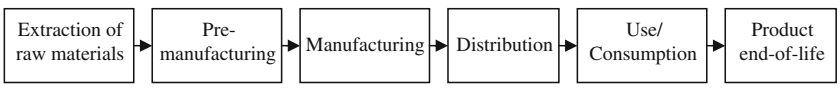

Fig. 1 Generic supply chain extended to use phase/consumption and product end-of-life

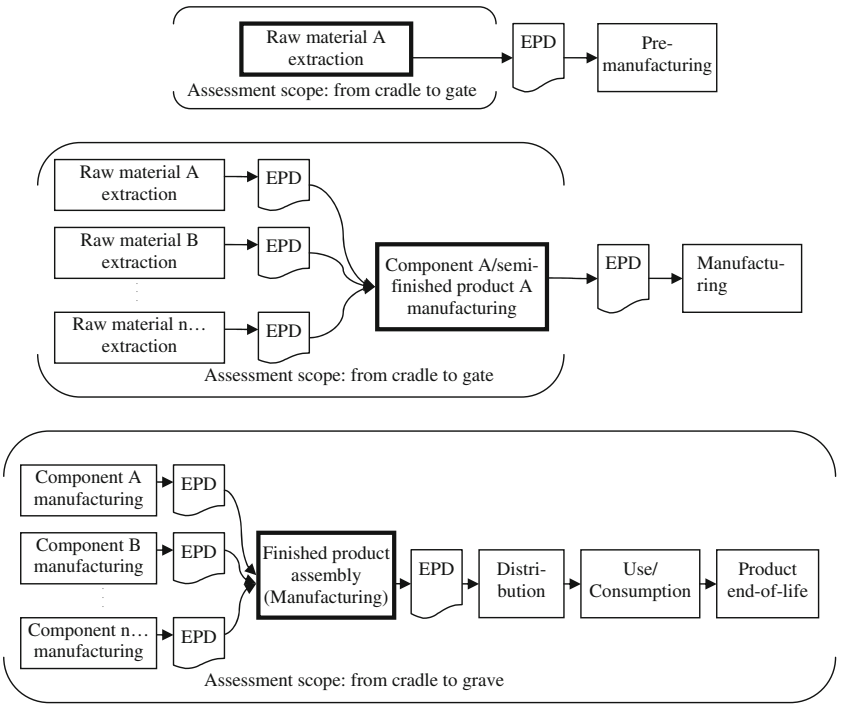

Fig. 2 Supply chain stages, assessment scope and EPD delivery flow. Assessment scopes are highlighted for extended supply chain actors other than those involved in the distribution phase and product end-of-life. Although only key product flows are shown in this figure, supplies of energy and ancillary materials, freight transport and waste management have to be considered as part of each stage of the supply chain plus product end-of-life

decrease the market prices of their products. One way to solve this problem—at least partially—is to make EPDs publicly available. Inserting multi-impact environmental information on product label and organisation's could, in fact, support consumers and other stakeholders in making informed choices.

6 Assessing the methodology proposals through a case study

This section shows how the methodology proposals illustrated in the sections 5.1 and 5.2 can work in practice. For this purpose, we simulated a case study on road freight transport in Europe. In particular, the VAT rate was calculated for a new 23 t total capacity truck produced by a certain motor company. The environmental performance was calculated on the basis of the following unit of analysis: transport of 1 kg of drinkable water through a 23 t total capacity truck for a distance equal to 1,000 km. Data presented below are just given for an illustrative purpose and may not reflect the reality.

To apply the equations illustrated in section 5, the following assumptions were given:

- VAT is applicable to transport services;
- All transport modes belong to the same product category;
- Reference datasets for freight transport modes are those presented in Table 1;
- Eurostat's modal distribution of freight transport (% tkm) in EU-27 is presented in Table 1 (Huggins 2009);
- Impact categories, assessment methods, and normalization factors for EU-27 are as in CML2001—Dec. 07;
- All impact categories are supposed to be equally important and, thus, the weighting factor is 1 for all categories;
- The environmental performance of the analysed truck is 10 % less than the performance of the dataset "GLO: Truck 20–26 t total cap./17.3 t payload/Euro 2 PE" from GaBi Professional database (PE International, 2007). *GWx* is, thus, equal to 0.057 kg CO_2-Equiv., whilst *Ix* is the sum of the normalised data shown in Table 2;
- *VATsr*=20 %.

Before applying equations for calculating *VATx* to the case analysed, it was needed to calculate *Ia* and *GWa* first. Based on the EPDs collected from the preceding year, the public authority for the new VAT framework should be in charge of issuing annually a reference environmental performance indicator for each product class (i.e. *Ia* or *GWa*).

These benchmarks can be obtained in different ways. For this purpose, the reference environmental performance has been calculated for each freight transport mode first. This was done by compiling the inventories of each transport mode according to the parameters chosen for the unit of analysis (i.e. transport of 1 kg of cargo for a distance equal to 1,000 km). Then, characterization results were calculated per each freight transport mode and normalized (see Table 1 for characterization results concerning global warming potential and Table 3 for normalization results concerning the entire suite of impact categories in CML2001—Dec. 07).

To obtain *Ia*, a single score indicator per each transport mode was calculated by summing the normalized data

Table 1 Reference datasets, characterization results for global warming[a] and modal distribution of freight transport in EU-27

Transport mode	Reference dataset	Global warming potential (GWP 100 years) [kg CO2-Equiv.]	Modal distribution of freight transport (% tkm) in EU-27 (Huggins 2009)
Air	Airplane jet—cargo (average) (EC, 2011a, b)	2.068	0.1
Rail	GLO: Rail transport cargo—average (PE International 2007)	0.026	10.5
Sea	GLO: Bulk commodity carrier (average)/coast (PE International 2007)	0.008	37.3
Road	GLO: Truck 20–26 t total cap./17.3 t payload/Euro 2 (PE International 2007)	0.063	45.6
Pipeline	Pipeline average (PE International 2007)	0.008	3.2
Inland waterway	Average ship/1,228 t payload/canal (EC 2011)	0.026	3.3

[a] Characterization results are shown per unit of analysis

(normalized data in Table 3 were added up column by column because environmental issues were assumed to be equally important).

Three hypothetic scenarios for *Ia* were then outlined by calculating:

- The arithmetic mean and median of the single score indicators;
- The average of the single score indicators weighted by the market shares of freight transport modes in EU-27 (see third column in Table 1).

As shown in Fig. 3, the median and weighted average gave similar results. Both options sound thus reasonable for arriving at reference environmental performance (benchmark), although choosing the weighted average would be more prudent because it is slightly smaller than the median. From an economic point of view, the arithmetic mean does not seem a suitable option. As shown in Fig. 3, only air transport, in fact, is above the arithmetic mean threshold and should be taxed for VAT accordingly. As the market share of this freight transport mode has been very limited in Europe so far, this scenario is not sustainable from an economic point of view.

Table 2 Normalization results and single score indicator of the product analysed

Impact category indicator	Normalization results
Acidification Potential (AP)	2.75E-14
Eutrophication Potential (EP)	4.39E-15
Freshwater Aquatic Ecotoxicity Pot. (FAETP inf.)	1.27E-16
Global Warming Potential (GWP 100 years)	1.09E-14
Human Toxicity Potential (HTP inf.)	2.07E-16
Marine Aquatic Ecotoxicity Pot. (MAETP inf.)	2.26E-14
Ozone Layer Depletion Potential (ODP, steady state)	1.40E-17
Photochem. Ozone Creation Potential (POCP)	1.24E-14
Terrestric Ecotoxicity Potential (TETP inf.)	2.46E-16
Single score indicator (*Ix*)	*7.84E-14*

Alternative to *Ia*, *GWa* was calculated by following the same logic illustrated above, but with a focus restricted to characterization data for global warming only (see Table 1). In particular, three hypothetic scenarios for *GWa* were delineated by using the arithmetic mean, median and weighted average. As shown in Fig. 4, the three scenarios look similar to those analysed for *Ia* above. The only difference is that the weighted average is slightly bigger than the median in this case and, thus, the latter option should be preferred.

In conclusion, it looks like there is no unique way to come up with applicable *Ia* and *GWa*. The weighted average, in fact, seems working better in some cases, whilst in some others the median is preferable. Product groups should be, thus, studied individually in order to identify the most prudent calculation option for *Ia* and *GWa*. For our case study, the weighted average and median were selected for representing *Ia* and *GWa,* respectively (i.e. *Ia*=7.66E-14; *GWa*=0.026).

VATx can be now obtained by using either Eq. (1) or Eq. (2). Results have been rounded off and are expressed in decimal form.

According to Eq. (1), *VATx* can be derived from *Ia* and *Ix* as follows.

$$VATx = VATsr - \left(\frac{Ia - Ix}{Ia}\right)$$
$$= 0.2 - \left(\frac{7.66\text{E}{-}14 - 7.84\text{E}{-}14}{7.66\text{E}{-}14}\right) = 0.22$$

According to Eq. (2), *VATx* can be derived from *GWa* and *GWx* as follows.

$$VATx = VATsr - \left(\frac{GWa - GWx}{GWa}\right)$$
$$= 0.2 - \left(\frac{0.026 - 0.057}{0.026}\right) = 1.41$$

Table 3 Normalization results and single score indicators per freight transport mode

Environmental issue	Normalized data per freight transport mode					
	Air	Rail	Sea	Road	Pipeline	Inland waterway
Acidification	4.80E-13	1.06E-14	1.19E-14	3.05E-14	2.88E-15	2.04E-14
Eutrophication	7.29E-14	6.77E-16	9.59E-16	4.88E-15	1.04E-16	3.11E-15
Freshwater Aquatic Ecotoxicity	3.95E-15	1.22E-16	1.83E-17	1.41E-16	4.07E-17	6.01E-17
Global Warming	3.97E-13	4.91E-15	1.58E-15	1.21E-14	1.52E-15	4.96E-15
Human Toxicity	3.14E-15	1.95E-16	2.59E-17	2.30E-16	6.60E-17	8.07E-17
Marine Aquatic Ecotoxicity	7.59E-13	1.93E-13	3.21E-15	2.51E-14	6.89E-14	1.03E-14
Ozone Layer Depletion	3.89E-16	6.72E-16	1.99E-18	1.56E-17	2.41E-16	6.37E-18
Photochem. Ozone Creation	1.87E-13	4.61E-15	4.53E-15	1.38E-14	1.03E-15	1.16E-14
Terrestric Ecotoxicity	7.87E-15	2.44E-16	3.52E-17	2.74E-16	8.21E-17	1.13E-16
Single score indicator per transport mode	1.91E-12	2.15E-13	2.23E-14	8.71E-14	7.48E-14	5.06E-14

Although the service analysed is performed by an eco-friendly truck (its environmental performance per unit of analysis is 10 % lower than the road freight transport reference performance), the *VATx* rates from Eq. (1) and Eq. (2) result greater than the standard VAT (i.e. *VATsr*). This is due to the fact that other freight transport modes—some of which are characterised by reference datasets having a better marginal environmental performance than road transport—were considered within the same product group.

7 Conclusions

The sustainable development challenge that many countries are currently facing worldwide needs stronger measures. This, in particular, refers to climate change and those other environmental issues for which time for mitigation is inexorably running out. One of the most effective ways to address this challenge is adopting the life cycle perspective. This has been pointed out in the EU already in 2003 by the adoption of the Integrated Product Policy.

In this paper we built on that and later policies to present a possible LCA-based framework to radically change our current production and consumption patterns. In particular, we showed that a new VAT taxation framework can be built upon the LCA methodology and may form the basis of a life cycle-based sustainable economy. In a broad sense, the new VAT taxation framework is in line with the "getting prices right" policy of the Community Sustainable Development Strategy (EC 2005a, b). In the way to develop this framework, special emphasis was given to some methodology

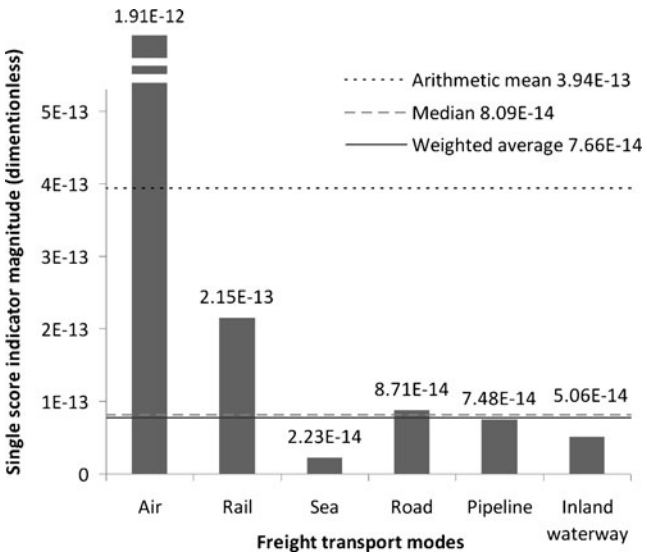

Fig. 3 *Ia* as arithmetic mean, median and weighted average of the single score indicators per transport mode

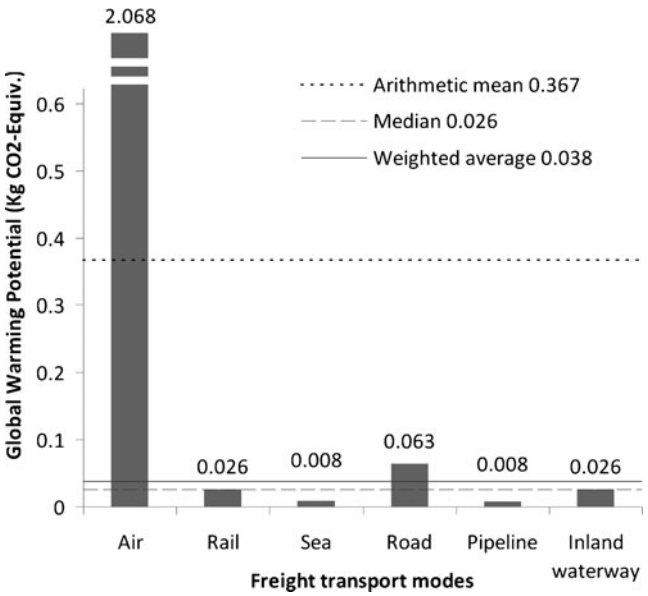

Fig. 4 *GWa* as arithmetic mean, median and weighted average of the single score indicators per transport mode

proposals to differentiate VAT rates according to LCA and carbon footprint. In this context, fiscal neutrality issues related to State budgets have been also taken into account by delineating the basic needs for more cautious methodology proposals to differentiate VAT rates (see section 5.3).

Nonetheless, a detailed impact assessment procedure for this novel policy instrument is necessary before its endorsement. In particular, potential consequences from the enforcement of the new VAT framework solutions should be carefully evaluated. This detailed impact assessment should also include the considerations of the international trading agreements and rules. Although WTO has relaxed its position towards the trade barriers linked to the environmental concerns, it is still an important factor to consider in the future impact assessment procedure. Another element is the complementarily of the proposed VAT framework with other environmental taxation systems running in parallel. In fact, although the proposed VAT framework aims at influencing the consumers' behaviour, while the existing EU Emissions Trading System (ETS) targets the producers' environmental impact on climate change, the combination of the two systems may put an extra burden on consumers. As highlighted by Smale et al. (2006), in fact, businesses involved in the ETS tend to pass on the costs of their emissions permits to customers. Moreover, the application of the new VAT framework to specific sectors and products should be evaluated on a case-by-case basis, and exceptions should be possible. For example, if applied to foods and drinks, the new fiscal framework has the potential to change dietary habits of people and even lead to malnutrition. This is to be avoided.

If the new VAT framework were found suitable by policy makers, the stakeholders concerned should set out a suite of measures to fine-tune, test, establish and facilitate the implementation of this green VAT framework.

First of all, organisations should become sensitive to the challenge of this new VAT framework. Organisations are a key actor because they are those expected to make big efforts to run detailed assessments enabling to identify product specific VAT rates. Moreover, the burden of the new environmental accounting would complement the current accounting system. These elements may be perceived negatively by many companies (especially SMEs), although the cost of this additional burden may be much smaller than the environmental benefits achievable from the implementation of this system, and although companies have already showed in the past their capability to cope with this type challenge when the general accounting system was introduced.

To facilitate the introduction of this new VAT framework, governments should play a major role in settling the right conditions for rendering the system workable. For this purpose, a detailed roadmap should be outlined. This may include the following actions:

- Filling those research gaps that may prevent the use of LCA in fiscal policies (e.g. refinement of some impact assessment methods may be needed to provide results with minimum degree of uncertainty).
- Development of sectorial and product-specific guidelines to implement environmental assessments in a coherent and comparable manner. The effectiveness of these guidelines should be tested by running pilot studies.
- Development of guidelines on how to deal with the lack of control on the environmental product declaration from some developing countries.
- Identification of reference datasets for energy carriers, consumption patterns, product end-of-life and so forth.
- Development of publicly available tools for managing data from different sources, running product environmental assessments (reporting included) and eco-design procedures, and calculating product specific VAT rates.

Given the possible significant impact on the society, this fiscal framework should be introduced gradually. However, the process may be smoother in those countries having a mandatory product environmental declaration system already established or on the way to be established, see e.g. the novel French labelling scheme laid down in the national law generally known as Grenelle de l'Environment (Cros et al. 2010; French Parliament 2010). Introducing a mandatory EPD system may be a crucial milestone towards the full implementation of the new VAT framework.

In parallel to the implementation of the new VAT framework, policy makers may use the environmental product declarations for banning from the market the most environmentally damaging products within each product group. This would be possible by setting up thresholds concerning the worst admissible product environmental performance.

The framework illustrated in this paper may be further developed and fine-tuned by introducing social aspects in the underlying methodology for differentiating VAT rates.

Acknowledgements The authors thank the anonymous reviewers for their valuable inputs.

Camillo dedicates this paper to Paolo Frasca, graduated in environmental economics and died prematurely in July 2006.

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